SARDI

Spawning biomass of Jack Mackerel (*Trachurus declivis*) in the East sub-area of the Small Pelagic Fishery during summer 2019

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SOUTH AUSTRALIA

Government of South Australia
Primary Industries and Regions SA

SARDI
R&D
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Jack Mackerel (East)

DEPM Surveys

Egg surveys

2002 & 03 - spring

NSW
Sydney
Jervis Bay
Eden

Jack mackerel eggs
October 2002/2003
× 0
○ 0 - 1
○ 1 - 10
○ 10 - 100
○ 100 - 1000
○ 1000 - 5000

2003 & 04 - summer

NSW
Jervis Bay
VIC
Eden
TAS

Jack mackerel eggs
February 2003/2004
× 0
○ 0 - 1
○ 1 - 10
○ 10 - 100
○ 100 - 1000

2014 - summer

Eggs density
(eggs per square metre)
· 0
○ 0 to 5
○ 5 to 10
○ 10 to 50
○ 50 to 500

2019 - summer

SST (°C)
25
24
23
22
21
20
19
18
17
16
15
14
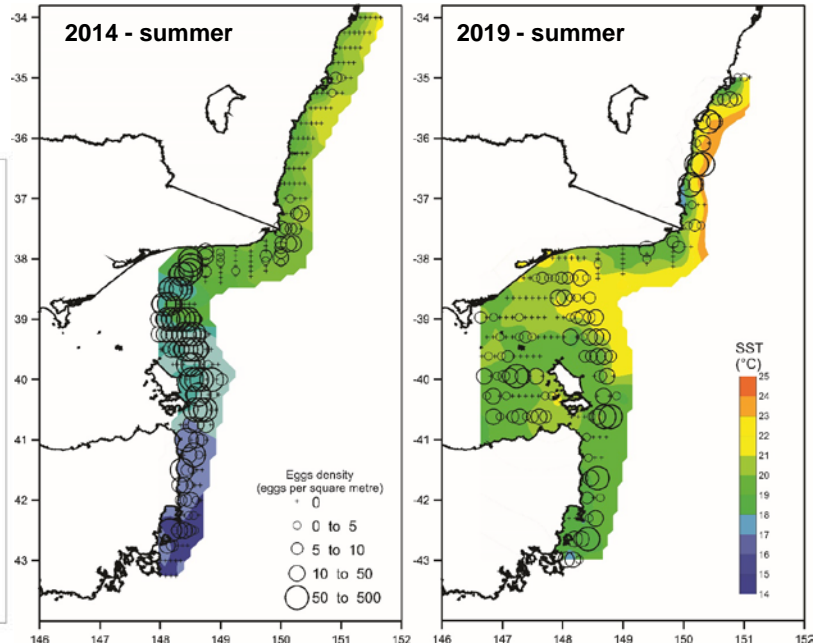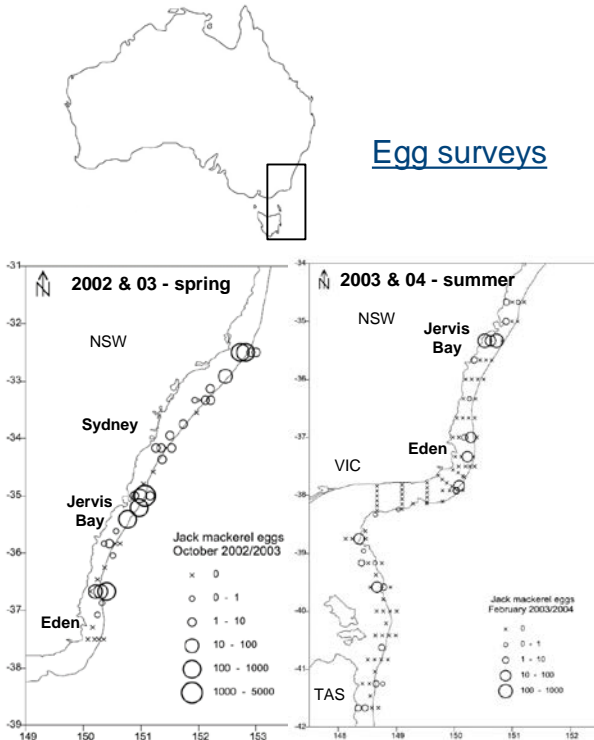
2002:
- Oct (Neira et al. 2011)
- 2,627 live eggs from 36 of 43 stations
- Spawning Area: 21,327 km^2

2014:
- Jan
- 3,530 live eggs from 117 of 292 stations
- Spawning Area: 23,553 km^2

2019:
- Jan-Feb
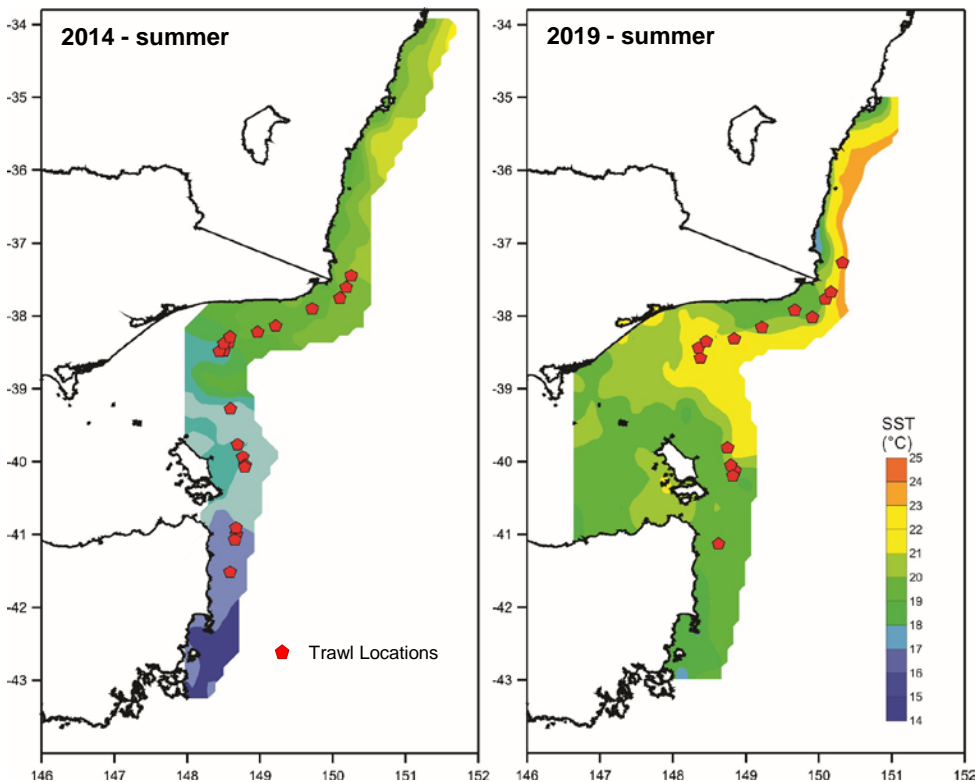- 921 live eggs from 107 of 206 stations
- Spawning Area: 36,100 km^2

Jack Mackerel (East)

DEPM Surveys

Adult surveys

2014 - summer

2019 - summer

SST (°C)
25
24
23
22
21
20
19
18
17
16
15
14

Trawl Locations

2019:
- S.E. Australia (Jan-Feb)
- Demersal trawl
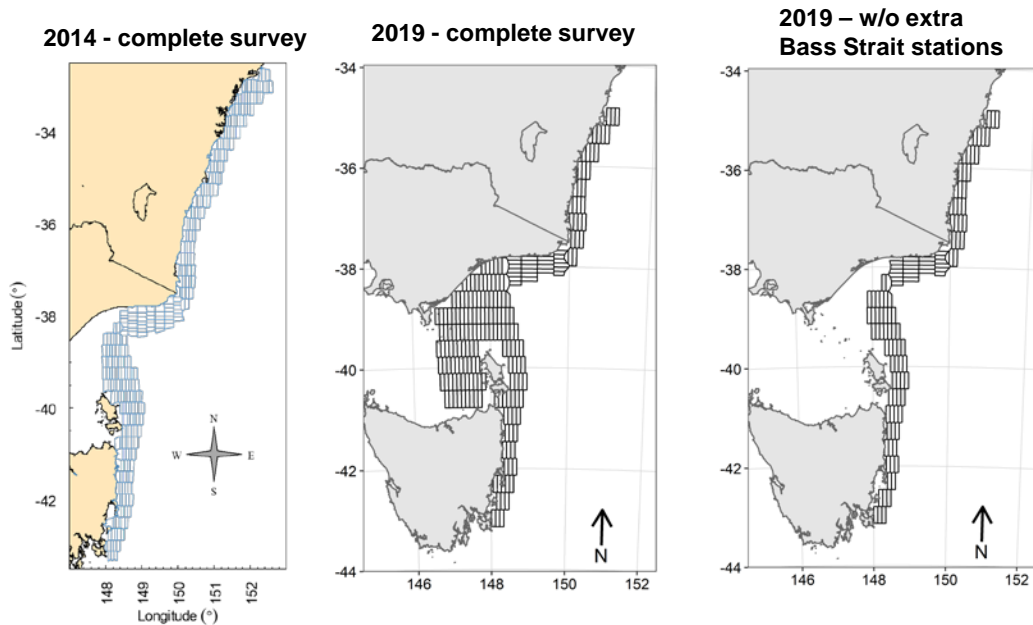- Female n = 575
  (12 samples, total n: 1,087)

2014:
- S.E. Australia (Jan)
- Demersal trawl
- Female n = 1,285
 (16 samples, total n: 2,704)

2001-2004:
- S.E. Australia
- Purse seine and mid-water trawl
- Female n = 100

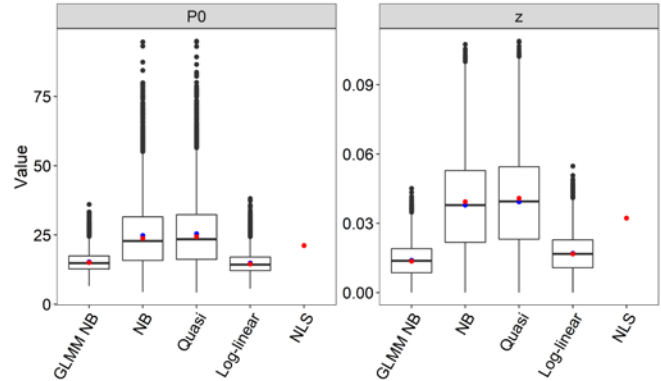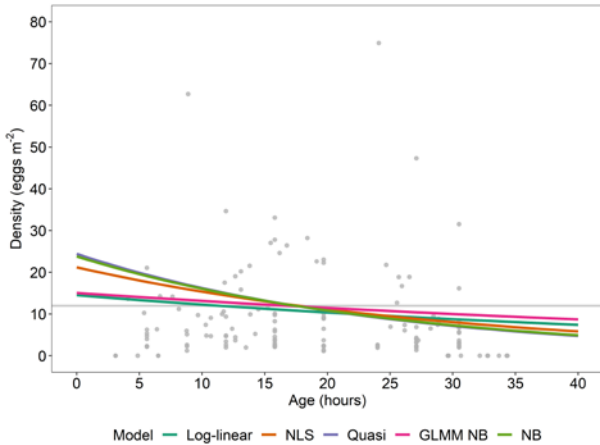# Total Survey Area & Spawning Area

2014 - complete survey

2019 - complete survey

2019 – w/o extra Bass Strait stations

	Area sampled (km²)	Spawning area A (km²)	Percentage of area sampled	Spawning biomass (t)
2014	63,355	23,553	37.2	157,805
2019	68,295	36,100	52.9	156,292
2019 (without Bass Strait)	37,339	23,639	63.3	-

DNA Confirmation of Jack Mackerel Eggs
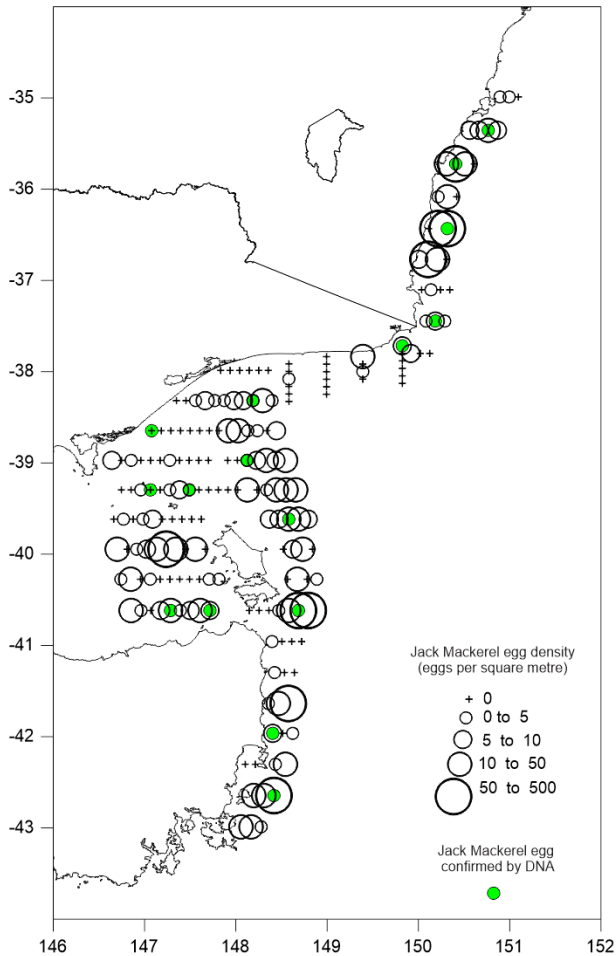
Visual Identification	DNA Confirmed Jack Mackerel	Not Jack Mackerel (DNA)
Jack Mackerel	28	1
Uncertain	25	10
unlikely	1	7

Jack Mackerel egg density
(eggs per square metre)

+ 0
○ 0 to 5
○ 5 to 10
○ 10 to 50
○ 50 to 500

Jack Mackerel egg
confirmed by DNA

Egg Production P_0

Egg Production Model	P_0 eggs·day^{-1}·m^{-2} (95% CI)	z
Log-Linear	14.5 (8.8-23.8)	0.017
Non-linear Least Squares	21.2 (-)	0.032
Quasi GLM	24.4 (8.3-54.3)	0.041
GLMM NB	**15.1 (9.4-23.5)**	0.014
Negative Binomial GLM	23.8 (8.4-53.2)	0.040

General Linear Mixed Model (GLMM)
Negative Binomial error structure

2019 = 15.1 eggs·day^{-1}·m^{-2}
2014 = 28.9 eggs·day^{-1}·m^{-2}

(Average NLS, GLM Quasi x 2)

Adult Samples & Female Weight *W*

Samples	Male			Female		
	n	Average FL (mm)	Average weight (g)	n	Average FL (mm)	Average weight (g)
1	7	222	108			
2	39	198	80	19	207	96
3	61	207	90	70	210	88
4	13	222	112	17	219	108
5	2	221	117	3	217	100
6	132	228	124	139	228	119
7	74	232	130	100	237	139
8	30	233	133	43	240	141
9	53	234	148	98	237	145
10	3	259	184	4	255	177
11	11	248	173	7	236	141
12	87	217	112	86	223	117
Total	512	223	119	586	228	**126.3**

Latitude

Depth

Jack Mackerel (East)
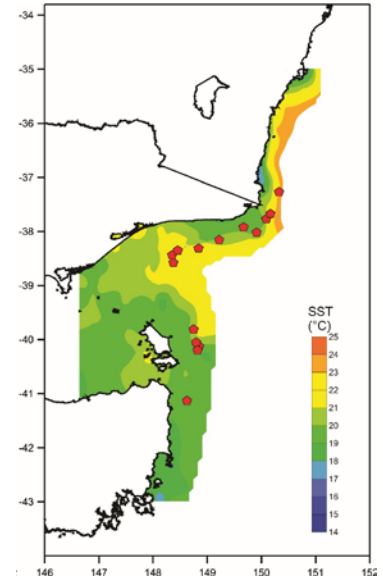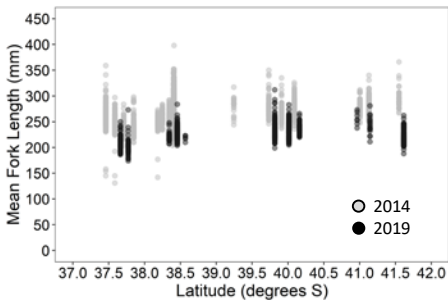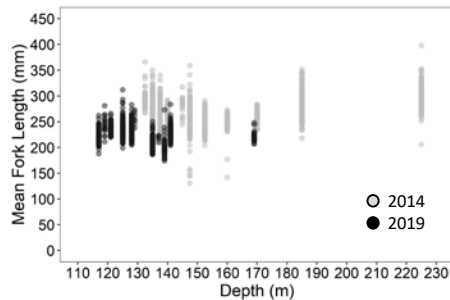
Length Frequency: DEPM Samples

Research Demersal Trawl
(2014 DEPM survey)

Eastern Victoria/southern NSW
Above 39˚S
(n = 1,759)

North-eastern Tasmania
Below 39˚S
(n = 947)
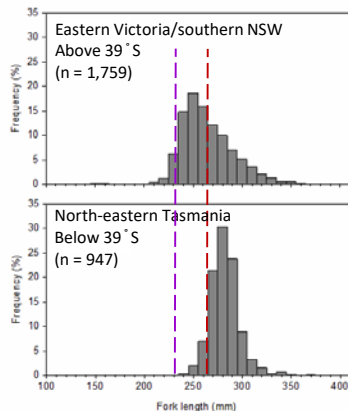
- January 2014
- Between St. Helens & Eden
- Data: SARDI

Research Mid-water Trawl
(2019 DEPM survey)

Eastern Victoria/southern NSW
Above 39˚S
(n = 578)

North-eastern Tasmania
Below 39˚S
(n = 591)
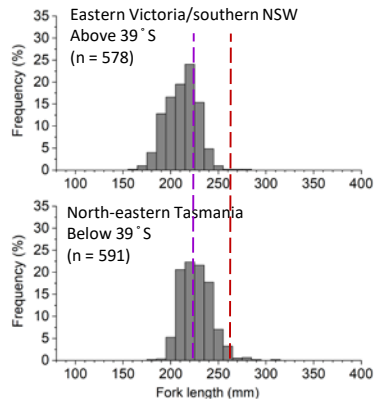
- Jan/Feb 2019
- Between St. Helens & Eden
- Data: SARDI

– – Female size at maturity in 2014 DEPM (~ 268 mm FL)

– – Mean size of mature female in 2019 DEPM (228 mm FL)

Batch Fecundity *F*

Current Batch Fecundity Relationship
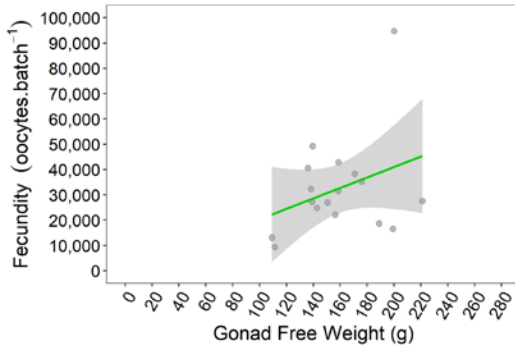
F = 25,212 eggs per batch

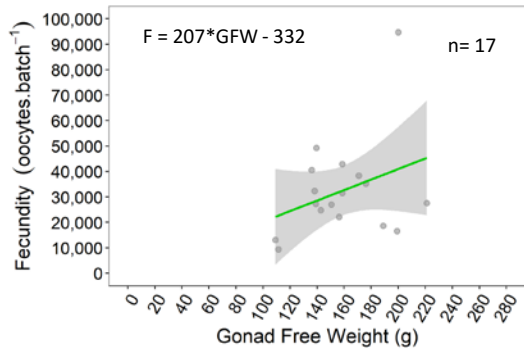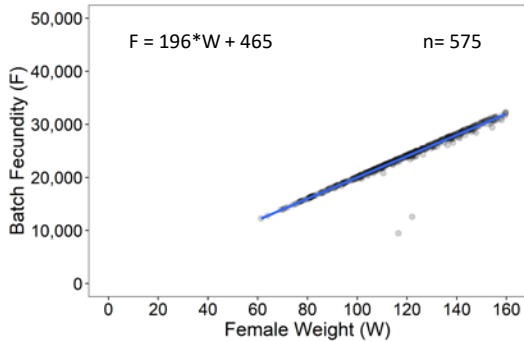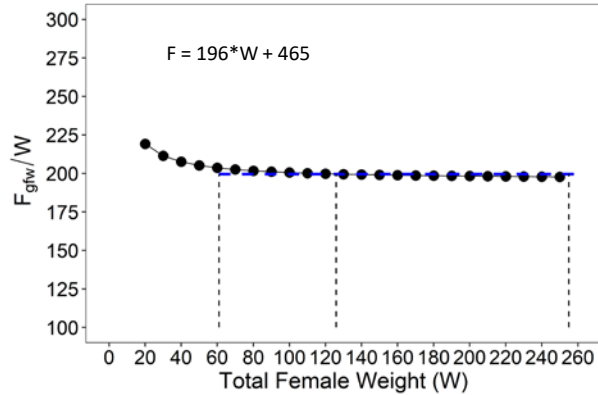## Comparisons
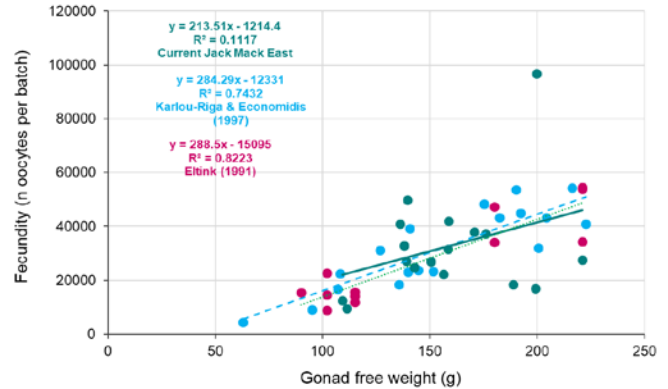
Closely related species
- *Trachurus trachurus*

Relative Fecundity (F/W)

F = 207*GFW - 332   n= 17

Fecundity (oocytes.batch^{-1}) vs Gonad Free Weight (g)

F/W = 199.6

F = 196*W + 465

F_{gfw}/W vs Total Female Weight (W)

F = 196*W + 465   n= 575

Batch Fecundity (F) vs Female Weight (W)

F/W is effectively constant
Can be calculated as single parameter
Increased precision (reduced 95% CI)

Sex Ratio *R*

Samples	Female		Male		
	n	Average weight (g)	n	Average weight (g)	R
2	19	96	39	80	0.36
3	70	88	61	90	0.52
4	17	108	13	112	0.56
5	3	100	2	117	0.57
6	139	119	132	124	0.50
7	100	139	74	130	0.59
8	43	141	30	133	0.61
9	98	145	53	148	0.65
10	4	177	3	184	0.57
11	7	141	11	173	0.35
12	86	117	87	112	0.50
Total	586	126.3	505	119	**0.546**

2019
R = 0.546

2014
R = 0.47
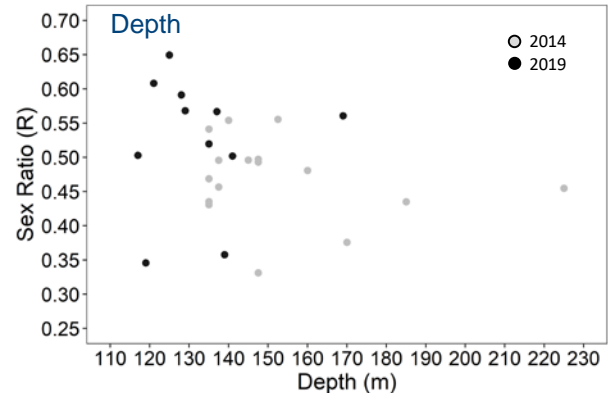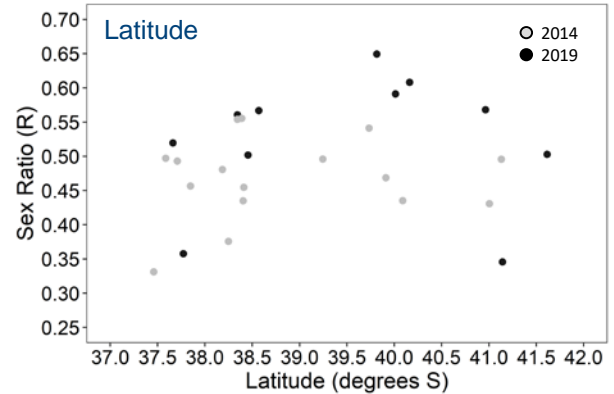
Spawning Fraction *S*

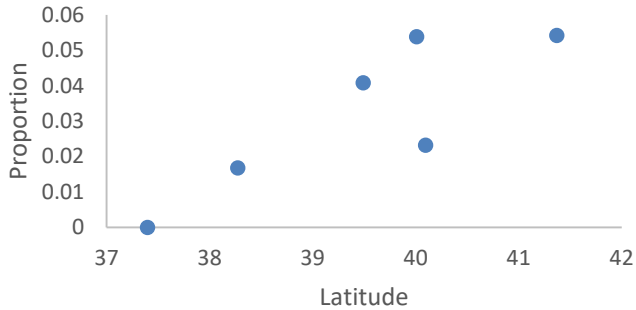| Samples	n	Total POFs	S
2	18	0	0.000
3	67	0	0.000
4	17	0	0.000
5	3	1	0.111
6	137	7	0.017
7	98	16	0.054
8	43	3	0.023
9	98	12	0.041
10	4	1	0.083
11	7	2	0.095
12	83	14	0.056
Total	**575**	**56**	**0.032**

2019
S = 0.032

2014
S = 0.056
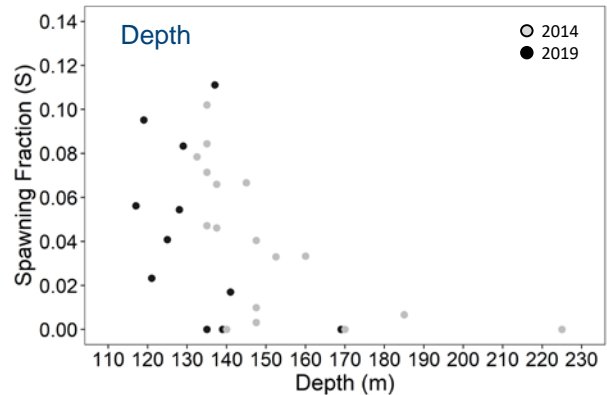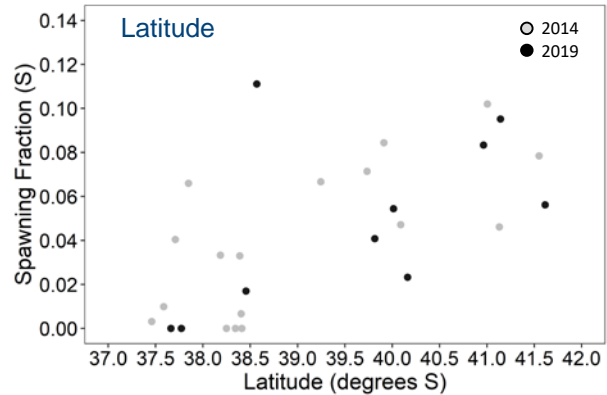
Latitudinal gradient in *S*
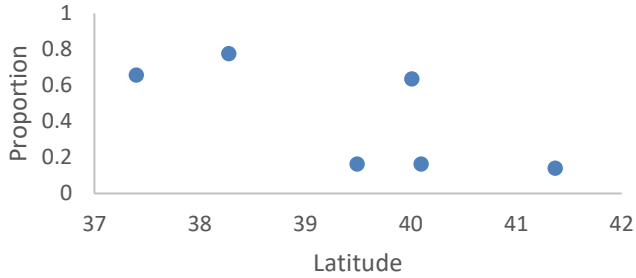
Missed peak spawning season?
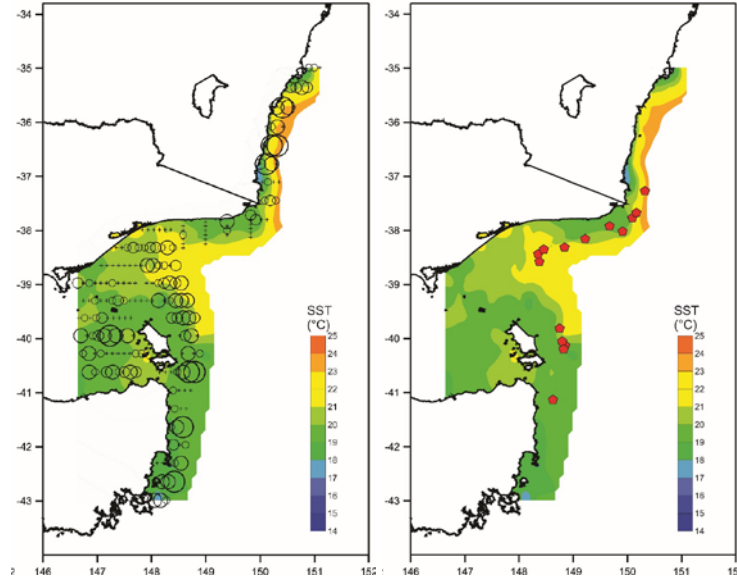
Spawning Biomass & Parameter Values

Spawning Biomass	**156,292 t** (95% CI = 49,120–263,496)

| Parameter	Symbol	Units	Value	95% CI
Egg Production	$P_{0\ (GLMM\ NB)}$	eggs·day^{-1}·m^{-2}	15.1	8.0–22.2
Spawning Area	A	km^2	36100	-
Sex Ratio	R	-	0.546	0.49–0.60
Spawning Fraction	S	-	0.032	0.016–0.048
Fecundity	F	eggs·female^{-1}	25,212	13,570–36,854
Female Weight	W	g	126.3	68.3–184.3
	F/W	eggs·g^{-1}	199.6	179.1–220.1

Jack Mackerel (East)

DEPM Survey (2019)
Sensitivity analysis

2019 SB estimate: **156,292 t**

Adult parameters in sensitivity analysis:

- **Solid**: 2019 survey estimates

- **Dashed**: 2014 survey estimates

- **Dotted:** Alternate model estimates of P_0 in 2019

- **Blue**: mean S (2014 & 2019)
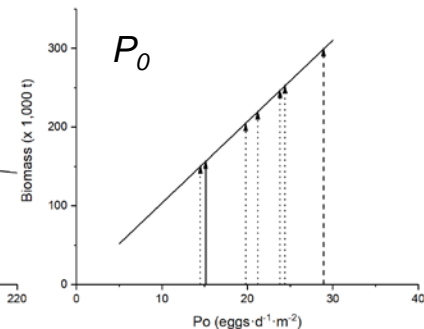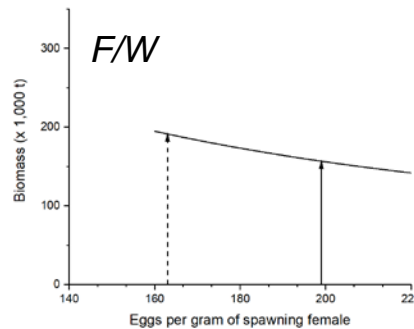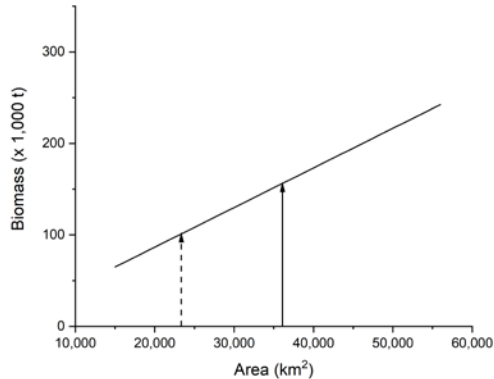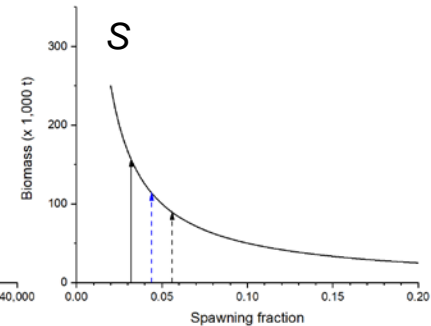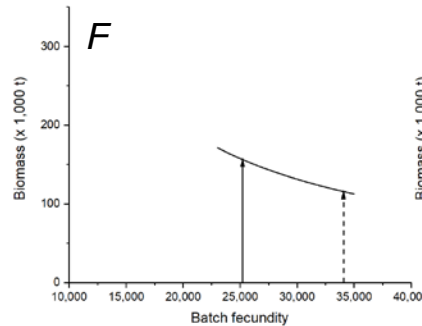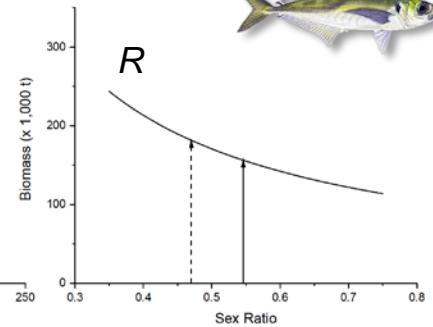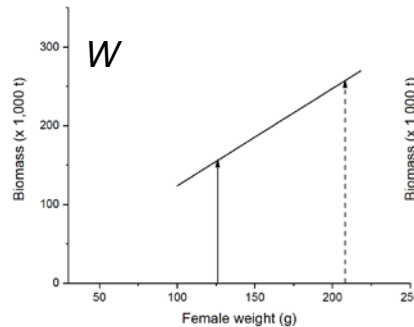
Conclusions

- Improved coverage of the spawning area (c.f. 2014)

- Lower P_0 and S in 2019 than 2014 (also higher atresia)

- Likely missed peak spawning season

- No reduction in spawning area from consistent survey area

- Spawning area effective proxy for spawning biomass

- Need to better understand variability in P_0 and S

- Then can convert spawning area into spawning biomass with greater confidence

- Key challenge – latitudinal gradient in S

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